HABITAT COMPENSATION CASE STUDY ANALYSIS

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ABSTRACT

In Canada, the *Fisheries Act* together with the No Net Loss (NNL) Principle require that fish habitat altered, disrupted, or destroyed as a result of human activities be compensated. Habitat deemed to be impacted by human activity is compensated according to a hierarchy of compensation options that ranges from replacing destroyed habitat with similar habitat to artificial propagation. A Department of Fisheries and Oceans (DFO) National Habitat Compensation Initiative (NHCI) was undertaken and guided by a working group. The NHCI undertook a review and discussion on the policies, procedures, legal, and scientific/technical aspects of compensation guidelines under the *Fisheries Act* and the Policy for the Management of Fish Habitat.

This report attempts to synthesize patterns in both the implementation and perception toward habitat compensation by DFO staff. Patterns in 'implementation' was examined from selected 'case' projects where compensation was used. We examined 'perceptions' by analyzing patterns in discussion topics of DFO staff while at regional workshops on compensation issues.

The case study analysis demonstrated substantial variation in frequency of hierarchy level used among regions and nationwide. The size of compensation ratios (ratio of habitat compensated versus that impacted) differed substantially among as well as within regions. In addition, compensation ratios tended to be dramatically reduced in projects with 'Harmful Alteration Disruption or Destruction' (HADD) areas greater than 30,000 m^2, suggesting that the ability to apply 'No Net Loss' is very difficult in large projects. Finally, an examination of compensation success, although limited by the lack of data, demonstrated that success varied widely.

The analysis of staff-perception toward habitat compensation demonstrated general agreement both among regional workshops and across specific case studies. In contrast to the case study analysis, no areas of substantial differences or variation were apparent.

Although patterns emerged from the case study analysis, the small number of cases and the absence of standardized data collection resulted in limitations that affected the extent of analysis and inferences. For these reasons, we recommend developing clear questions, formulating testable hypotheses, obtaining a large representative database of case studies, and using a meta-analytic comparative approach to provide scientifically defensible procedures and tools to habitat biologists.

We emphasize from the onset that this exercise is not exhaustive but simply a cursory examination of preliminary results to demonstrate the analysis and review step of an adaptive management approach.

RÉSUMÉ

Au Canada, selon la *Loi sur les pêches* et le principe d'aucune perte nette, il faut compenser toute détérioration, destruction ou perturbation de l'habitat du poisson causée par des activités humaines. Les mesures à prendre sont déterminées selon une hiérarchie d'options compensatoires, allant du remplacement de l'habitat détruit par un habitat semblable à la reproduction artificielle du poisson. Un groupe de travail a entrepris l'Initiative nationale en matière de compensation des pertes d'habitat (INCPH) du ministère des Pêches et des Océans. Dans le cadre de cette initiative, le groupe a examiné et débattu les aspects stratégiques, procéduraux, juridiques et scientifiques/techniques des lignes directrices prévues par la *Loi sur les pêches* et la Politique de gestion de l'habitat du poisson en ce qui concerne la compensation.

Le présent rapport tente de synthétiser les façons dont le personnel du MPO perçoit et met en œuvre les mesures de compensation des pertes d'habitat. On a examiné les tendances en ce qui concerne cette mise en œuvre en se penchant sur certains projets qui comportaient des mesures de compensation (étude de cas), tandis que les perceptions ont été étudiées en analysant des discussions tenues par le personnel du MPO lors d'ateliers régionaux portant sur la compensation.

L'étude de cas a montré d'importantes variations dans la répartition des différents niveaux hiérarchiques retenus d'une région à l'autre. Les ratios de compensation (ratio de l'habitat créé par des mesures de compensation sur l'habitat perdu) différaient beaucoup d'une région à l'autre ainsi qu'au sein d'une même région. En outre, les ratios de compensation avaient tendance à être très bas pour les projets où la détérioration, la destruction ou la perturbation de l'habitat (DDPH) touchait des superficies supérieures à 30 000 m^2, ce qui laisse croire qu'il est très difficile d'appliquer le principe d'aucune perte nette aux grands projets. Enfin, en se fondant sur des données limitées, on a montré que le succès des mesures de compensation variait beaucoup.

L'analyse de la perception du personnel a mis en évidence un consensus général qui se manifestait dans les différents ateliers régionaux et d'un projet à l'autre. Contrairement à l'analyse des projets, aucune variation importante n'était apparente.

Bien que l'analyse des projets (étude de cas) ait permis de dégager des tendances, le petit nombre de cas et le manque de normalisation dans la collecte de données a restreint la portée de l'analyse et des déductions qu'on pouvait en tirer. Par conséquent, nous recommandons d'élaborer des questions claires, de formuler des hypothèses vérifiables, de créer une grande base de données représentative sur des études de cas et d'utiliser une approche comparative méta-analytique afin de fournir aux biologistes de l'habitat des procédures et des outils scientifiquement fondés.

Nous soulignons que la présente démarche n'est pas exhaustive; il ne s'agit que d'un examen superficiel de résultats préliminaires qui vise à faire la démonstration des étapes d'analyse et d'examen d'une approche de gestion adaptée.

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1.0 INTRODUCTION

Wide-spread fish population and species extinction have led governments in the U.S.A. and Canada to developed legislation to conserve and protect essential fish habitat (Beneka 1999) and system productivity (Minns 1997) from the effects of human activity. In Canada the Fisheries Act prohibits the "harmful alteration, disruption or destruction" (HADD) of fish habitat, unless specifically authorized. As such, when an unavoidable loss of productive capacity is proposed, the Department of Fisheries and Oceans (DFO) preferentially requires that 1) the project be relocated or redesigned to avoid loss of habitat, 2) that there be a mitigation plan in effect to reduce loss of habitat, and finally 3) that unavoidable losses to habitat be compensated according to a hierarchy of compensation options that ranges from replacing destroyed habitat with similar habitat to, as a last resort, artificial propagation. The Policy for the Management of Fish Habitat (DFO 1986) outlines, through the No Net Loss (NNL) working principle, that when authorizations for the destruction of fish habitat are issued, proponents must demonstrate via habitat compensation that their projects lead to "no net loss in the productive capacity of fish habitat". This report focuses on an examination of this last requirement; namely habitat compensation.

A DFO National Habitat Compensation Initiative (NHCI) was initiated and a working group formed to initiate a review and discussion on the policies, procedures, legal, and scientific/technical aspects of compensation guidelines under the *Fisheries Act* and the Policy for the Management of Fish Habitat. This report and a companion report by Cudmore-Vokey *et al.* (2000) address some scientific and technical aspects of compensation. The report presented here synthesizes patterns in both the implementation and perception toward habitat compensation by DFO staff through an examination of 1) selected 'case' projects where compensation was used, and 2) the comments of DFO staff on representative case studies while at regional workshops on compensation issues. Specifically, in the first part on case studies, we examined a) the usage of the hierarchy of compensation options, b) proportional surface area of habitat lost versus that compensated and c) the overall success of projects where compensation occurred. In the second part we examined commonalties and differences between regions in the answers given by staff to a set of questions relating to five example case studies. These five case studies represented projects from offshore oil and gas, oil and gas pipelines, whole lake destruction, dam repair, and hydroelectric development. By bringing together an analysis of case studies and meeting discussions, we highlight similarities and differences between perceptions of habitat management staff (discussions) as well information on what is done in the field (case studies).

2.0 METHODS

2.1 Data (source and type)

Data used to examine patterns in the application and perception toward habitat compensation came from two sources, case studies and workshop discussions. In addition, summary data from the Habitat Referral Tracking System (HRTS) database for 1998-1999 is presented to provide a background on the number of referral projects across Canada that DFO assesses (Table 1).

2.1.1 Case studies

Raw data collected for the case study analysis were gathered from representative examples of habitat compensation within each of six regions including Newfoundland, Maritimes, Laurentian, Central and Arctic, Ontario, and Pacific. We separated Ontario from the Central and Arctic region to examine specific patterns in this province. Formal selection criteria for case studies were not established. However, case studies tended to include 1) recent and old habitat compensation projects conducted in the region, 2) examples of compensation that were successful and unsuccessful, 3) compensation projects that were difficult to deal with, and 4) the type of compensation that occurs most often in a region. The working group designated the information to be assembled for each case study. Each region submitted a set of studies with slight variation from this protocol, with potential repercussions on the analysis. However, since formal statistical selection criteria were not established, statistical techniques were not used. Instead, general patterns and correlation were examined and represented graphically.

The raw case study data were assembled in a relational database to facilitate reporting, access, and querying of information. A total of 122 case studies were gathered from the regions of Newfoundland (n=12), Maritimes (n=30), Laurentian (n=25), Central and Arctic (n=32 of which 21 are in Ontario), and Pacific (n=23). For each case study, data was gathered on location (coordinates, HRTS number), HADD (size, type, composition), compensation (size, hierarchy, ecosystem), and monitoring (success, objective, duration, etc.).

2.1.2 Workshop discussions

The second data set consisted of answers to eight questions posed for each of five case studies representing projects from offshore oil and gas, oil and gas pipelines, mining, dam emergency repair, and hydroelectric development. The questions were asked of Fish Habitat Management and Science staff during regional NHCI

workshops (1999-2000) in Halifax, Winnipeg, and Vancouver. The questions were developed by Dr. C.K. Minns in consultation with Gordon Ennis (NHCI Chair) and Jean Ogilvie (facilitator). The data set of questions and answers is included in Appendix A to summarize perceptions of habitat management practitioners. The answers to questions from each workshop were used to highlight regional similarities and differences in techniques, experience, and perspectives on habitat compensation. This approach also captures information on strengths and weaknesses of current compensation methodologies, documentation, and science as well as discrepancies in interpretation. This information was used to examine the needs of staff in completing their daily tasks pertaining to compensation.

2.2 Case study analysis

We evaluated patterns in the application of hierarchy of compensation options, compensation ratios, and overall success of projects where compensation occurred, within and among the five DFO regions plus Ontario.

2.2.1 Hierarchy

For each case study we assigned a position in the compensation hierarchy according to Table 2 and the opinions of the regional staff in charge of the compensation project. The total sample size for the hierarchy database is 150 while the total number of cases is 122. There are more hierarchies than total case studies because many projects reported using more than one level in the hierarchy. There are seven levels in the compensation hierarchy (Table 2).

Patterns in assignment of compensation hierarchy within regions were examined visually using pie charts. The surface area of the pie chart represented the total number of compensation projects for a region. Individual pie clusters represent the proportion of that region's projects that were of a given hierarchy level.

Patterns in assignment of compensation hierarchy among regions were also examined visually in a pie chart. The surface area of the pie chart represented the total number of compensation projects across Canada. Individual pie clusters represent the proportion of projects (regardless of region) that were of a given hierarchy level.

In order to examine robustness in the application of hierarchy levels, we independently evaluated the hierarchy level of each case study according to the criteria established in the section "Defining Compensation Hierarchy" (Appendix B). Case studies where our evaluation was different than that of the region are examined in greater detail in the results section.

2.2.2 Compensation ratios

The relationship between the surface area of compensation habitat and the surface area of habitat lost through a HADD was examined with a ratio as follows:

$$\text{Compensation ratio} = \frac{AreaCompensation}{AreaHADD}$$

The pattern of distribution of this ratio was examined among regions. In order to examine the pattern in compensation ratios across a range of project size, raw surface area data were examined in a bivariate plot of compensation area versus HADD area. Readers should be aware that since compensation ratios are not explicitly mentioned in DFO policies or the *Fisheries Act*, inherent variations in ratios among regions will be apparent.

2.2.3 Success

The evaluation of a compensation case as a success (defined by regional offices as good, fair, poor) or failure was rarely reported (32 out of 122 reported success). However, the pattern in success was examined for regions lumped together and separately with the use of pie charts. The surface area of the pie chart represented the total number of cases where success was reported. Individual pie clusters represent the proportion of cases with a given success type.

2.3 Workshop discussions

The National Habitat Compensation Initiative organized regional workshops to bring together Fish Habitat Management and Science staff together to discuss a wide range of compensation issues. In order to focus the workshop discussions, a sub-sample of five case studies (from the section above) were selected and participants were asked to answer eight questions on each of the case studies. The questions asked for each case study were:

1. What indicates there is a HADD?
2. What determines acceptability of any mitigation measures?
3. Does FHM give guidance on mitigation choices?
4. What determines acceptability of HADD?
5. Under what circumstances would DFO reject a request to authorize a HADD (exclusion)?
6. How is the level in the compensation hierarchy arrived at?

7. What is FHM role in giving guidance on compensation options?

8. How is the amount of compensation arrived at?

Similarities and differences in the answers among the three regional workshops were summarized and synthesized to identify problems and concerns as well as strengths and weaknesses of habitat compensation procedures.

3.0 RESULTS AND DISCUSSION

A geographical map of case studies is included to provide perspective on sample size and location (Figure 1).

3.1 Case study analysis

3.1.1 Hierarchy

The case studies demonstrated substantial variation in the use of hierarchy of compensation options (Figure 2 and 3). The top of the hierarchy (pie cluster 1) where like-habitat is created, was used most often in Newfoundland and Pacific, followed by Maritimes, Laurentian, and Central and Arctic. Increases in like-habitat productivity (pie cluster 2) was most often used in the Laurentian, Maritime, and Pacific regions. Unlike-habitat was rarely if ever created (pie cluster 3) in the Maritimes, Laurentian, and Newfoundland regions.

Nationwide, with data from all regions lumped together, the hierarchy level most often used was of increasing like-habitat productivity (29% occurrence). The second hierarchy used most often was creating or increasing habitat in a different ecological unit targeting the same species (25% occurrence). The third hierarchy of compensation used most often was to replace habitat for like-habitat (22% occurrence) (Figure 3).

The cause of the variability in the use of hierarchy levels across Canada was not evaluated in this exercise. However, it is possible that problems in defining and interpreting the hierarchy, lack of available literature and science (Cudmore-Vokey *et al.* 2000), and the high cost of acquiring dry land, contribute to the observed pattern. In addition, patterns among regions may also reflect actual geographical/biological differences. For example, proponents in regions where waterscapes are already man-made may be able to replace habitat with like-habitat whereas proponents in regions where unaltered systems exist may choose to increase habitat productivity instead.

We noticed under several instances that the hierarchy value that we assigned to a project differed from the value assigned by regional staff. Two case studies with different assignments are presented. The purpose of this exercise

was not to evaluate these particular case studies but merely to highlight differences in interpretation and encourage standardization by carefully defining ecological concepts.

Example 1: A case study described the replacement of a bridge crossing. The HADD was described as causing destruction of fish habitat through the permanent covering of substrate (mainly rubble). The compensation described building in-stream 'debris collectors' made of boulders and log stringers. The region placed this compensation as like-for-like. We categorized this compensation as an increase in productivity since the project occurred in the wet. We did not assign the increase in productivity as the 'same' or 'different' ecological unit because of the lack of data.

Example 2: A case study described the in-filling of a river bed for the construction of a spur-dyke. The compensation involved using riprap to provide fish habitat. The region found this project to create unlike habitat. We found this project to be an increase in unlike habitat productivity since the work occurred in the wet (i.e. new aquatic habitat is not 'created' from terrestrial habitat).

3.1.2 Compensation ratios

The amount of habitat compensated relative to the amount of habitat lost through a HADD is referred to in this report as the compensation ratio. A compensation ratio greater than one indicates that more habitat is created/replaced than is lost while a ratio less than one is a case when more habitat is lost than is created/replaced. Though compensation ratios are not discussed in DFO policies or the *Fisheries Act*, we examined patterns in ratios to stimulate discussions on the topic.

The size of compensation ratios differed greatly among as well as within regions (Figure 4). The Maritimes and Ontario have the highest mean compensation ratio (approximately 2:1) and smallest standard deviation from one project to another. Laurentian, Newfoundland, and Central and Arctic tend to have lower mean compensation ratios but higher variability about the mean. An example of this variability is in the Laurentian region where a ratio of 270 (mean of 1:1) was reported for a project. Newfoundland has one project with a ratio of 22 (mean of approx. 1:1) and Central and Arctic has at least one reported ratio of 10 (mean approx. 1:1). Pacific is an example of another region with a few widely skewed compensation ratios with one project reporting 125:1.

The variation in the use of compensation ratios did not seem to be explained by hierarchy level (Figure 5). Although no significant relationships were apparent between hierarchy levels, it is curious to note that those projects with 'increases in productivity' (hierarchy 2 and 4), consistently had a lower compensation ratio than those projects

where habitat was 'created' (hierarchy 1 and 3). Yet Minns (1995) demonstrated, with the use of productivity isolines, that large increases in unit productivity are required to offset habitat loss, whereas smaller increases in habitat surface area are required to offset the same loss. As such, if 'no net loss' is to be achieved, 'increases in productivity' should typically have larger compensation ratios than where habitat is 'created'.

Variability in compensation ratios is also apparent when looking at a bivariate plot of compensation area versus HADD area (Figure 6). In this figure, a straight line is apparent but the spread around this line and the presence of extreme outliers is also evident. Of particular concern is a break in the straight line for HADD projects with very large surface area (above 30,000 m^2). This curve in the line demonstrates that compensation ratios are dramatically reduced in projects with HADD areas greater than 30,000 m^2, suggesting that the ability to apply 'No Net Loss' is very difficult in large projects.

The change in the compensation ratio for large HADD areas could not be investigated in this exercise. This pattern should be carefully studied in order to ensure compliance with NNL policy, particularly in areas where large HADDs tend to predominate. Further, the reason for variation in compensation ratios as a function of hierarchy and region could not be examined in this study but should be the subject of scientific study in order to adjust for risk, uncertainty, and delays in the proper functioning of habitat.

3.1.3 Success

Success or failure of a compensation project is typically only reported for projects that have completed a portion of their monitoring program. Only 32 projects out of 122 reported some form of success and of these, most reported 'good' successes (Figure 7). A regional examination of patterns (Figure 8), although limited by the lack of data, demonstrates that success varied widely (Ontario was merged within Central and Arctic region due to lack of data). The Maritimes, Newfoundland, and Pacific reported that greater than half of their projects had good success. Laurentian reported half of projects with good success while the other half consisted of failures. Central and Arctic reported one quarter good success, another quarter of poor success, and a half with fair success.

Case studies should be treated as management experiments. Each decision made in a habitat compensation project could be categorized and used as a 'treatment' in a carefully designed experimental study. For this reason, the evaluation of a large sample size of case studies using a standardized evaluation protocol could be used as an

inexpensive way of testing which compensation management approaches offer the highest and lowest level of success.

3.2 Workshop discussions

Conceptually there appeared to be broad agreement in the responses of habitat staff for each of the eight questions, both among regional workshops and across specific case studies (Appendix A). No areas of substantial differences or variation were apparent; instead additional suggestions were made to highlight concerns or clarify a point. The following are a summary of the points made for each question. Referring to question 1, there was general agreement that a HADD consisted of any work performed in or near water that had impacted fish. Through question 2, it was found that the acceptability of mitigation measures to prevent a HADD was determined by a) the location and timing of the HADD activity, b) availability of good methods to achieve mitigation, and c) the absence of better alternatives. In addition, question 4 found that the criteria on the acceptability of a HADD was that the area impacted be small, that the area (habitat) not be critical to fish, that the area be of low productivity, or that the area not be used for any fishery. It was brought forward that some societal needs might potentially override acceptability of a HADD. Furthering this point was question 5 that focused on circumstances that would be considered an exclusion, where DFO rejects a request to authorize a HADD. There was agreement that an exclusion was present when a rare or unique species/habitat was involved or when high productivity existed. Again it was pointed out that societal (economic or political) reason could override an exclusion. Question 6 highlighted that selection of a hierarchy level for compensation (i.e. Table 2) was dependent on technological limitations and specific site conditions. Such a need for flexibility may suggest a need for both a general hierarchy coupled with a situational one. There was agreement on question 3 that FHM should give guidance on mitigation choices in a diversity of ways such as through guideline documents and consultation. Similarly in question 7, the role of FHM in giving guidance on compensation was favored to be in consultation and discussions, providing references and critiquing compensation plans. However, for compensation, it was suggested that FHM should have the additional role of negotiation and providing direction on development plans and monitoring. Answers to question 8 varied probably since the question on 'the amount of compensation for a given project' focused on compensation methodology (i.e. how?). Suggestions were made that monitoring identify the area required to replace the area lost through HADD. Some suggestions were made that compensation ratios should range from 1.5:1 to 2:1 (area compensated: area HADD). A general theme in answers to

question 8 was whether or not the amount compensated should be determined empirically or subjectively. For example, some suggestions were made that replacement should be a function of the area of the HADD, while some suggestions based replacement on the value of the original habitat and the proposed biological cost of the compensation.

3.3 HRTS miscellaneous descriptive data of background information

Examination of referral projects logged in the HRTS system demonstrates an important yet unused source of large amounts of data. This data could form the basis for a thorough comparative examination of habitat compensation in Canada. We illustrate the diversity and quantity of data in Table 1 and highlight a few features below. A total of 10,198 referrals were made in 1998 and 1999. Most of the referrals were made in the Pacific (37 %) and Ontario (25 %) regions, followed by Maritimes (16 %), Newfoundland (13 %), Central and Arctic (7 %) and Laurentian (1 %). Further, during the period 1998-1999, 367 authorizations were given, almost sixty percent of which were in Ontario.

4.0 Conclusions

"One gauge of the maturity of a scientific discipline is the extent to which results are synthesized across studies to test and refine the conceptual foundation of the discipline"
(Osenberg et al. 1999).

The Department of Fisheries and Oceans has made an important and decisive step in fostering the synthesis of research and management issues of fisheries habitat compensation in Canada. The procurement of this report demonstrates the Department's interest in examining past and current compensation practices for the benefit of aquatic habitat in Canada.

Although patterns emerged from the case study analysis presented here, limitations were apparent that affected the extent of analysis and inferences. For example, the small number of case studies and the absence of a standardized data collection and selection criteria resulted in a data set with unknown properties, and of questionable quality in terms of the data sets ability to represent the population of habitat compensation projects in Canada. Data selection criteria and sample size can profoundly influence findings generated from comparative studies (Englund *et al.* 1999) such as this case study analysis. Small changes in the selection criteria, differences in metrics taken from

each study, and small sample sizes can influence the detection power of statistical tests and bias the ability to detect patterns and trends. To be able to derive scientifically defensible results from a case study analysis, the appropriate data must be selected, the correct statistical technique must be used, an adequate question must be formulated and appropriate metrics selected. The relevance, quality, and dependence of the data must also be evaluated.

For these reasons, more detailed and scientifically defensible procedures must be undertaken to identify specific reasons to explain the patterns in the application of hierarchy chosen for a compensation, the amount of habitat compensated versus habitat that is lost, and the level of success experienced after a compensation has occurred. A scientifically designed meta-analysis of a large number of case studies should be able to provide answers to these questions.

5.0 Recommendations

Synthesizing the science and management behind compensation initiatives involves examining patterns in selected measures (metrics), testing hypotheses, and answering questions by comparing case studies instead of studying specific case studies in isolation. A comparative approach is required to synthesize how ecosystem as well as managerial processes and responses vary across ecological, political, geographical, and managerial systems. The analysis presented here cannot achieve these goals because of the small number of case studies and the absence of standardized data collection and selection criteria. However, by developing clear questions, formulating hypotheses, obtaining a large representative database of case studies and using a meta-analytic approach, these goals could be achieved.

In order to address these limitations we make the following recommendations.

1. Provide more specific operational definitions of ecological units, like versus unlike habitat, and creating versus increasing productivity.
2. Develop specific and testable hypotheses of National importance to focus questions and accumulate answers.
3. Log all referrals and habitat compensation in a data capturing system, perhaps as an extension to HRTS, and
4. Increase evaluation of habitat compensation techniques to complete the adaptive management feedback circle.

6.0 Acknowledgements

We would like to thank the National Habitat Compensation Initiative members and regional habitat management and science staff for their contribution of data, advice, and insight. We thank Wendy Morrell for providing HRTS data for all regions as well as Karen Calla, Ed DeBruyn, and Gordon Ennis for reviewing and helping improve this manuscript.

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Table 1 – Summary data of habitat referrals in 1998-1999 from the HRTS database. The proportion of referrals by region is summarized in the column labeled % of Total.

Region	% of Total	Roads	Power	Instream Works	Shoreline Works	Mining	Oil & Gas	Land Use	Non-referrals	Other	Total Referrals	Total Authorization
Ontario	24.57%	546	26	1038	0	117	206	114	446	13	2506	217
C & A	7.37%	0	0	0	752	0	0	0	0	0	752	95
Laurentian	1.33%	17	12	10	83	2	4	1	0	7	136	3
Maritimes	16.35%	468	17	547	423	8	51	62	0	91	1667	49
Newfoundland	13.31%	270	14	216	194	49	8	448	0	158	1357	3
Pacific	37.07%	438	39	785	577	562	20	615	0	744	3780	3
TOTAL	100.00%	1739	108	2596	2029	738	289	1240	446	1013	10198	370

Note: The 'other' category includes referrals related to aquaculture and forestry.

Table 2 – Hierarchy preferences for habitat compensation (adapted from Department of Fisheries and Oceans, 2000).

Number	Hierarchy
1	Create like habitat
2	Increase like habitat productivity
3	Create unlike habitat
4	Increase unlike habitat productivity
5	Create or increase habitat in a different ecological unit, same species
6	Create or increase habitat in a different ecological unit, different species
7	Rare measures*

* Rare measures include such things as deferred compensation, restoration of contaminated areas, or artificial production.

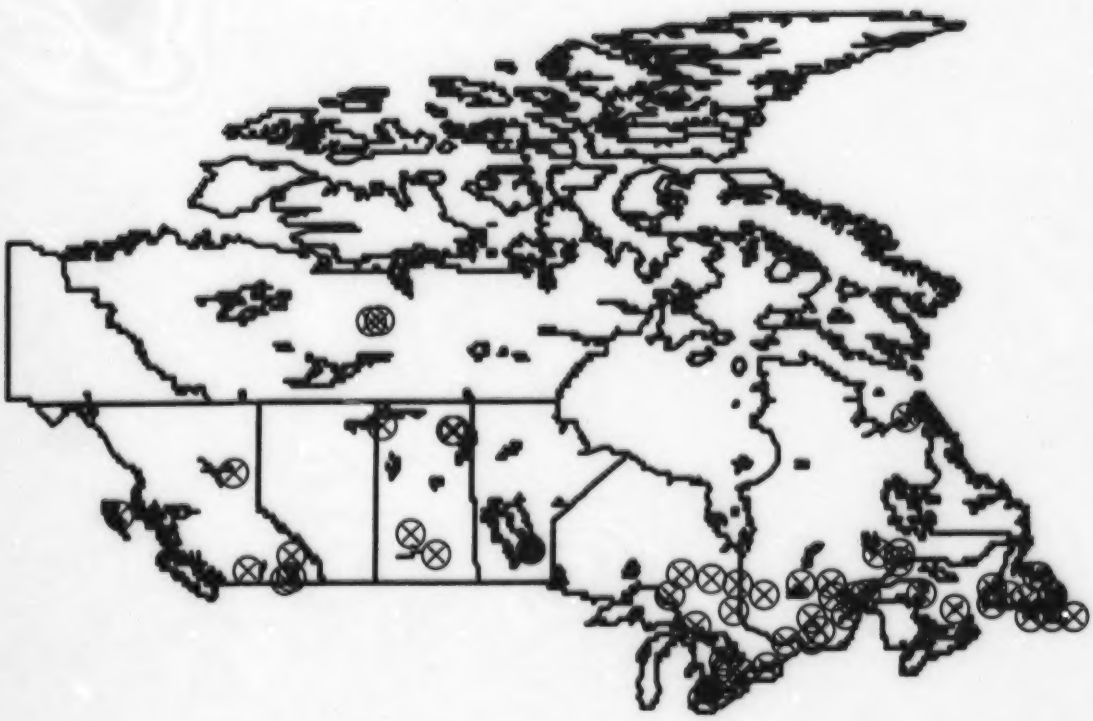

Figure 1 - Geographical distribution of case studies.

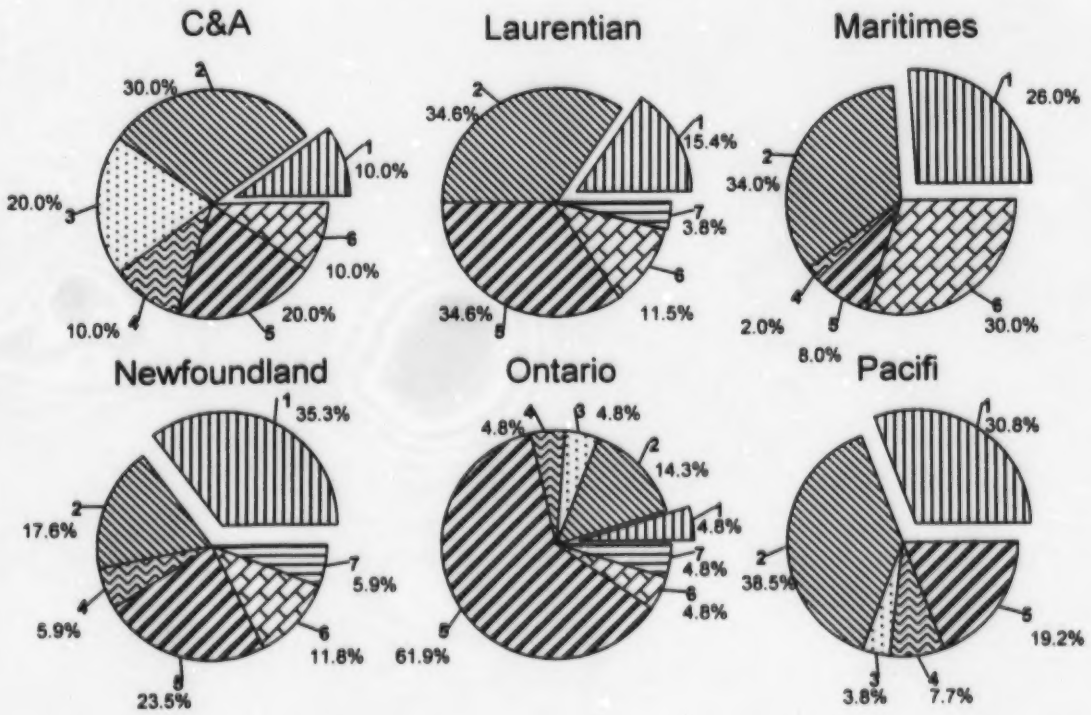

Figure 2 - Regional use of compensation hierarchy. Numbers represent the hierarchy according to Table 2.

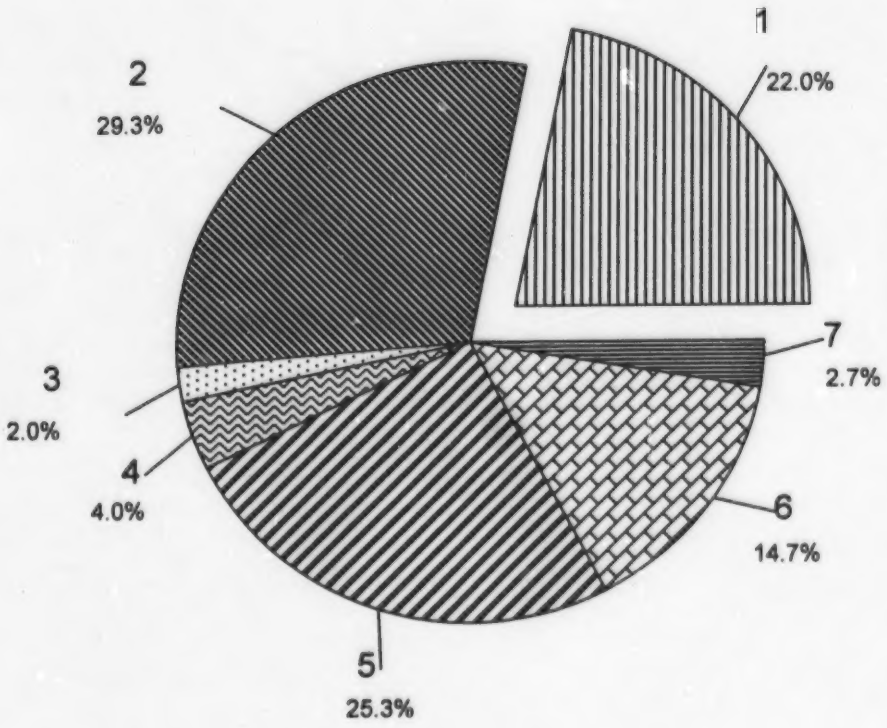

Figure 3 - Use of compensation hierarchy levels for all regions combined. Numbers represent the hierarchy number according to Table 2 (N=122 case studies reporting 150 hierarchy levels).

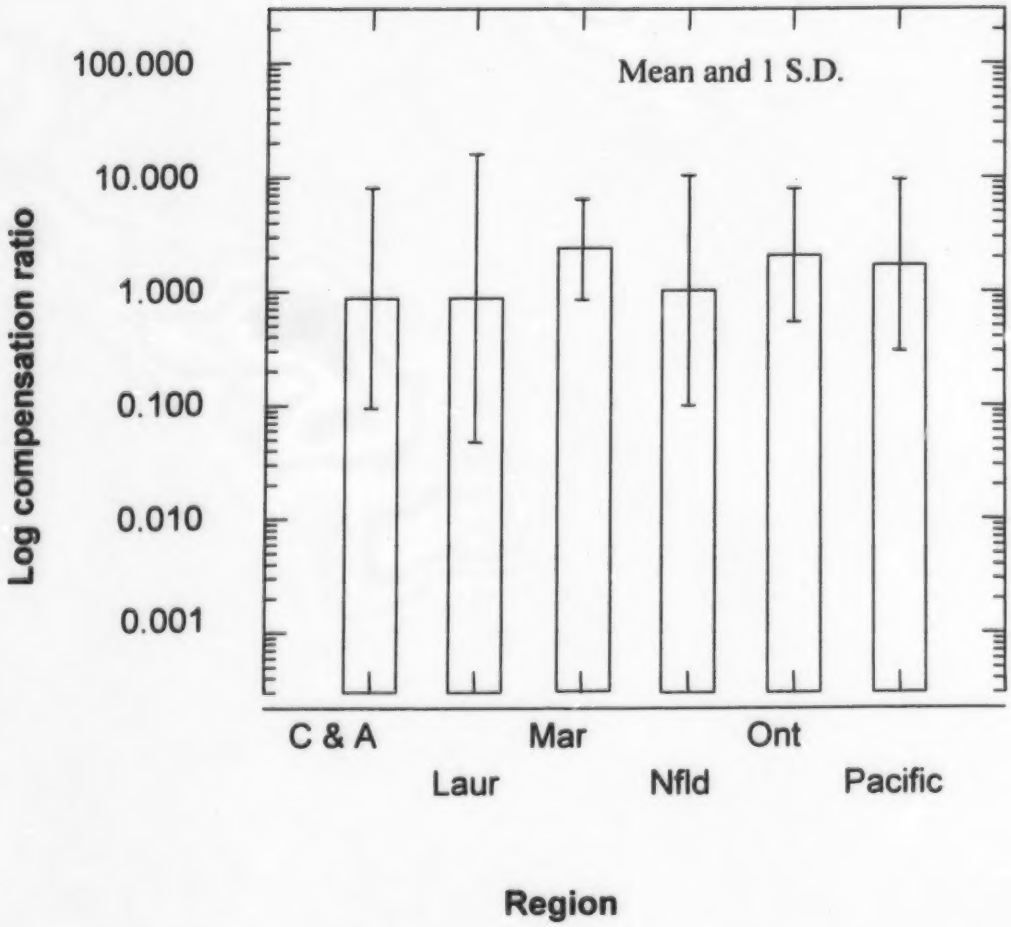

Figure 4 - Regional pattern in use of compensation ratio with Ontario separated from C & A.

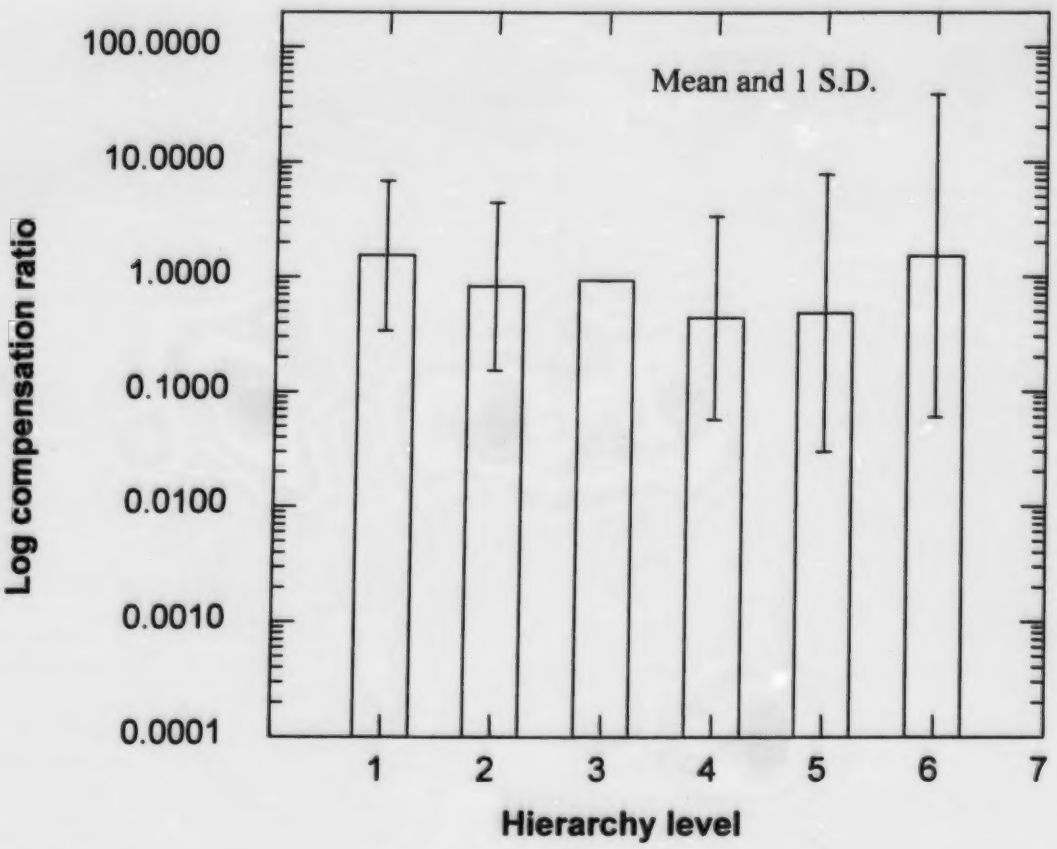

Figure 5 - Pattern in use of compensation ratio as a function hierarchy level.

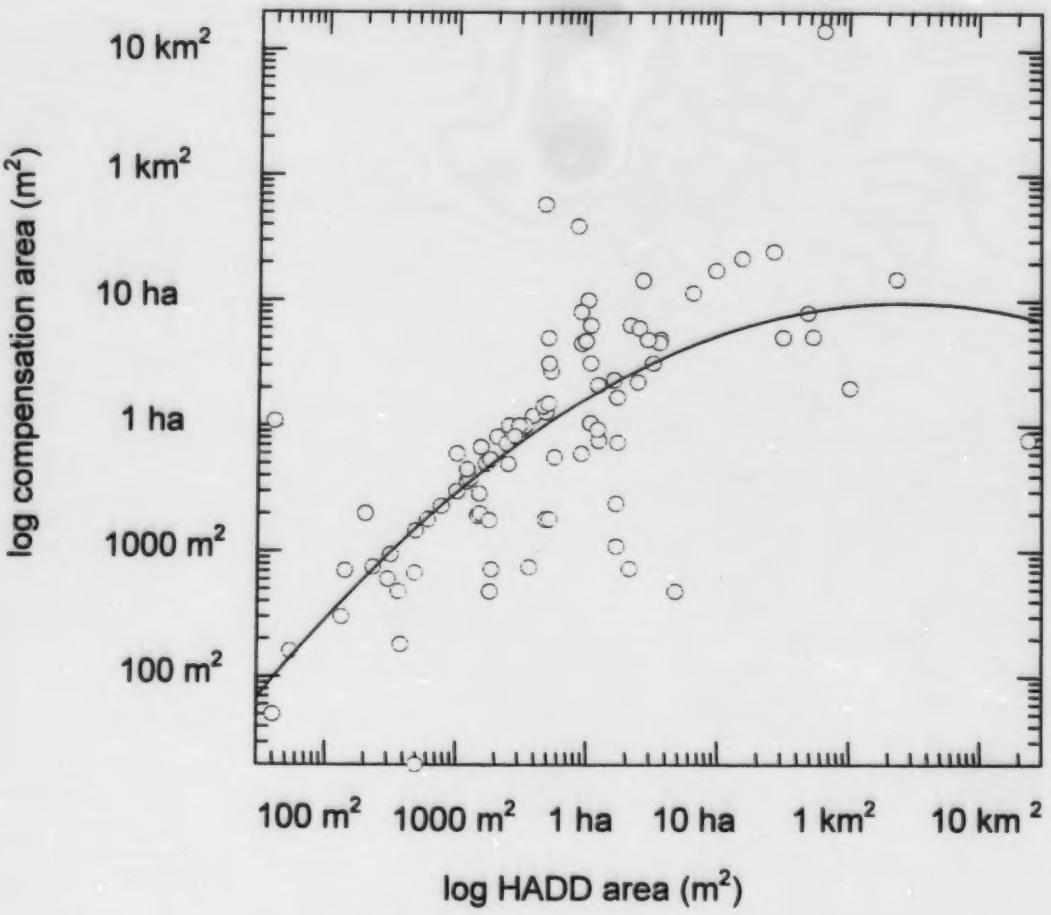

Figure 6 –Pattern in compensation area as a function of HADD area.

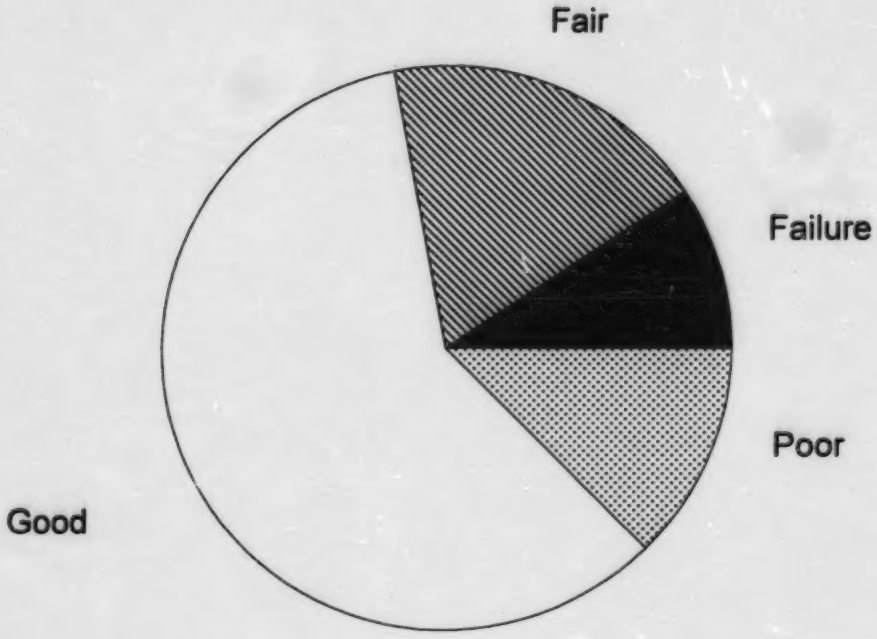

Figure 7 - Success reported for case studies for all regions together (n=32 out of 122)

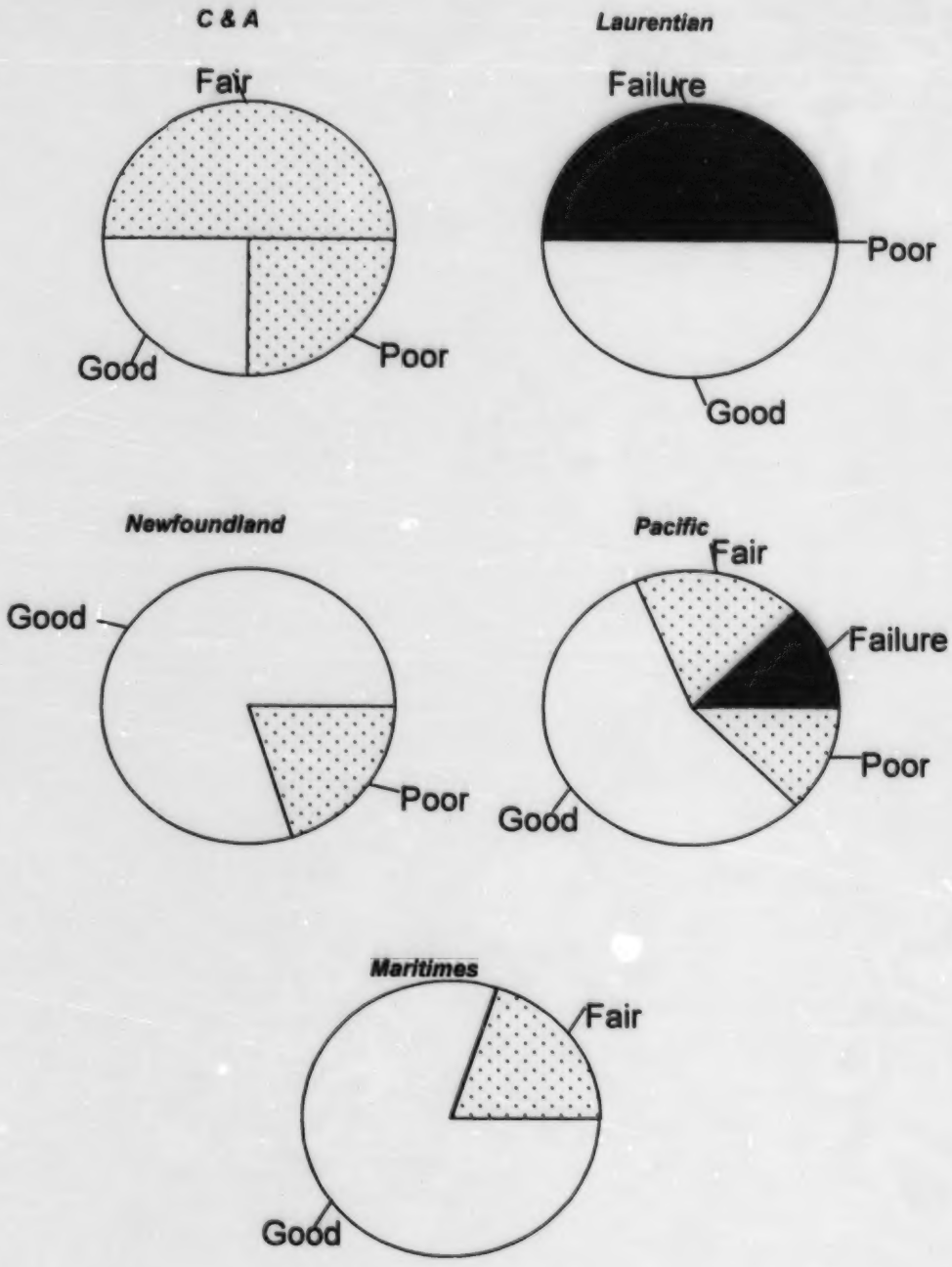

Figure 8 - Success reported for case studies separated by region.

Appendix A – Consolidated workshop discussion on case studies

Consolidate points across three workshops for each case study. Superscripts **Hal, Win, Van** stand for the workshops in Halifax, Winnipeg, and Vancouver respectively.

Questions:

1. What indicates there is a HADD?
2. What determines acceptability of any mitigation measures?
3. Does FHM give guidance on mitigation choices?
4. What determines acceptability of HADD?
5. What circumstances constitute exclusion (e.g. "highly productive")?
6. How is the level in the compensation hierarchy arrived at?
7. What is FHM role in giving guidance on compensation options?
8. How is the amount of compensation arrived at?

Consolidated answers to questions

Question	Main areas of Agreement	Main areas of Variance $[\frac{Among\ \mathrm{Re}gion}{AmongCaseStudy}]$
1.	• Any work performed in or near a 'wet' area with potential long or short-term impacts (defined as changing what is currently there) to fish.	
2.	• Location and timing of activity • Availability of best methods • Availability of alternative options	
3.	• Guideline documents available • Consultation available	
4.	•	• Guidelines limited, guidance mainly in the form of requested Environmental Management Plan
5.	• Small area impacted • Area not critical • Low productive capacity • No active fishery	• Societal needs potentially override acceptability of HADD
6.	•	
7.	• Exclusion when presence of unique or rare species/habitat • Exclusion when high productivity, economics, or policy related decision	
8.	• Technological limitations and site conditions	
9.	• FHM is involved in consultation, discussions, and negotiations. • FHM can provide legal wording, outline DFO expectations, give examples, references, and critique compensation plans	• Directives on type and size of habitat compensation and monitoring required.
10.	•	• If emergency work then broad agreement in the authorization followed by fine tuning.
11.	• Monitor to obtain data on the area required that would replace the area lost. • Focus is on single species replacement • Expected compensation ratio of 1.5:1 to 2:1 (area compensation: area HADD)	• Amount compensated based on value of original habitat (i.e. subjective vs empirical spatial replacement ratio).
12.	•	• Must consider cost or project (i.e. whole lake destruction).

Raw answers to questions highlighting areas of commonality by case study.

Case #1 – Offshore Oil and Gas

Question	Common	Additional
1.	• Physical excavation and dredge deposition in an area utilised by fish[Win,Van]	
2.	• Location and timing of activity[Hal,Win] • Availability of best methods[Hal,Win,Van]	• Presence of non-petroleum lubricants[Win] • Presence of water-based drilling muds[Win] • Presence of measures to minimize impacts[Win]
3.	• Yes, with Guideline docs[Hal,Win] • Consultation is available[Hal]	•
4.	• A relatively small area was impacted[Hal,Win]	• Dependent on how productivity was determined? [Van] • Questions on how the 1:50 ratio was determined[Van] • Have all technically/economically feasible mitigation methods been assessed? [Win] • Are cumulative impacts of potential concern? [Win] • The productivity is not unique [Win] • Compensation was feasible[Van]
5.	• Occurs where there is uniqueness/rarity of species[Hal,Win,Van] • Occurs where there is high productivity/economics (fisheries resource) or policy decisions[Hal,Win]	• Where there are unacceptable cumulative impacts[Win] • Community interactions/diversity[Win] • Not able to successfully create compensation scallop bed[Van] • Unacceptable risk of blowout[Van]
6.	• Arrived at due to technological limitations and site condition[Hal,Van] • Like-for-like not of any real benefit; not limiting, not highly productive, shift to inshore zone; create greater productivity[Win,Van]	• Next step in the process after avoiding and mitigating[Hal] • Previous attempt on-site did not work[Hal]
7.	• Consultation, discussion, negotiation[Hal,Win] • Legal wording, outlines DFO expectations (info requirements, alternatives) [Hal,Van]	• Integration of science, policy, public concern, into decision-making[Win]
8.	• Focus is on single species replacement[Hal,Van]	• Production estimate/area for key species? [Win] • Suggest area that would equate to that lost, then monitor[Win] • Question whether data suggests that near shore scallop bed will be 50X more productive than impact site? [Van] • Examine stocking density and site selection[Hal] • Cheaper to compensate in shore, monitoring easier and safer, easier fishery access[Hal]

Raw data Case #2 - Oil and Gas Pipeline

Question	Common	Additional
1.		• Transformation of habitat from wet to dry[Win] • Riparian habitat downstream not considered (should be)[Win] • Habitat is cut with blasting and excavation[Hal] • Important because of salmonid habitat[Hal] • Habitat is defined by "nursery, feeding and refuge" for game fish[Van]
2.		• No alternative location[Win] • Culverts are included to facilitate migration[Win] • No mitigation projected[Hal] • Unclear if the development is for a)benefits to society, b) politics[Van] • Importance of habitat[Van] • Likelihood of success of mitigation[Van] • Co-operation of proponent and sharing of cost[Van]
3.	• Yes, DFO info re fish migration and timing[Hal,Win]	• Culvert guidelines[Win] • Footprint design[Win]
4.	• HADD acceptable when it is not critical habitat[Hal,Win]	• No major hydraulic issues (consultation with engineer)[Win] • Is compensation within capability of proponent?[Van] • Is the HADD justifiable?[Van] • Has mitigation been fully explored?[Van]
5.	• Exclusion if "critical" or "highly productive" (assess on basis of local/scientific knowledge) ie. will there be impact on <u>any</u> life stage[Hal,Win] • Uniqueness of populations/habitats, rare or endangered species[Win,Van]	• Has proponent fully justified proposal? Considered all options?[Van]
6.	• Feasibility of compensation (sites, costs, durability)[Win,Van]	• Like for like[Win] • Abundant similar habitat exists; no gain in productivity[Win] • Opportunity for more productive/limited habitat creation[Win] • Actual compensation is combination of 3 hierarchy levels[Win] • X – in kind to augment productivity[Win] • X – out of kind habitat creation (dyke substrate)[Win] • √ - out of kind increasing productivity[Win]
7.	• Provide technical information, names of reference material, contacts, examples, etc.[Hal,Van] • Review proponents plan – change as see fit (experts' help)[Hal,Win]	
8.	• Ratio of 1:1.5[Hal]	• Only compensation was what proponent would have done anyway! (Culverts= mitigation)[Win] • Consider off site (eg. Tributary) riparian habitat works[Win] • Arial measures and ratios but depends on availability, etc.[Van]

Raw data Case #3 – Whole Lake Destruction

Question	Common	Additional
1.	• Lake and stream permanently lost; tailings, pit [Win,Van] • Valued ecosystem components and potential fisheries [Hal,Van]	• Area affected [Hal] • Duration of HADD/works [Hal] • Downstream effects [Hal] • Surface water and ground water plus ground water impacts [Hal]
2.	• No alternatives (unavoidable to drain the lake) [Hal,Win,Van]	• Demonstrate need for 12 lakes, can fewer be used via better techniques [Hal] • Consultation by DFO and proponent with experts pertaining to extent of impacts [Hal] • Mitigation/compensation options – decommission phase to (re-)create habitat [Win] • Assume sediments settling [Van] • Chemical impacts should have been mitigated [Van]
3.	• FHM gives guidelines, not direction [Hal,Win] • Only to limited degree; suggest proponent develop Environmental Management Plan with consultants from industry/private sector [Hal,Win]	• Ensure appropriate decommission (eg. littoral %) [Win] • Temporal replacement of habitat [Win] • End result guidance versus method approach [Win] • Opportunity to be more active in determining HADD (involve science) [Win] • DFO comments on: adequacies of EMP, issues DFO feels need to be addressed ie. Containment of HADD [Hal]
4.	• No active fishery [Win,Van] • Low productive capacity (group argues that it is a natural state for this region) [Win,Van] • Stakeholder input (provincial departments), public input/consultation (ie. Aboriginals) [Hal,Win]	• Potential of development of similar habitat [Win] • Availability of effective compensation (creation of habitat, reclamation of that lake) [Win] • N/B of the habitat type/quantity(?) [Hal,Win,Van] • Regional sustainable development plan in place or not [Win] • Lack of alternatives [Hal] • Containment of works from other habitats outside authorized scope [Hal] • Socio-economic (i.e. political) decision [Van] • Attempt at a biological rationale: [Van] • Many small, similar lakes, in area (group argues need to look at whole ecosystem) [Van]
5.		• Has to be highly productive lake fishery [Win] • significant public resistance [Win] • SARA (sensitive species, rare habitat) [Win] • Offsite impacts can not be mitigated [Hal] • Exclusion of site specific habitats ie. Critical habitats within the HADD [Hal] • Cumulative impacts [Van] • Insufficient information [Van] • Genetic diversity concerns [Van] • Compensation not feasible or available [Van]
6.		• No opportunities within the physical area of the HADD • No need – poor fishery • Move off-site to area of fishery • May be some opportunities in HADD if some areas have been excluded • Off the bottom of chart and money seems inadequate ($1 million) • Some doubt around who spends money and on what
7.	• Advise on hierarchy and fish habitat policy [Hal] • Up to developer to come up with options (based on policy guidance given) for DFO to review and make decisions on them [Van] • Critique compensation plan for usefullness/effectiveness [Hal]	• Negotiating [Win] • Direct proponent to community groups, stakeholders, aboriginals, etc. [Hal] • Opportunity to guide future compensation (power to direct compensation – science/sustainability programs/reclamation options) [Hal]
8.		• Value on habitat impacted (productivity, potential productivity [Win]

		• Value of fishery ($1.5 million), recreational/social [Win] • Unit area [Hal] • Sensitivity of habitat to undertaking [Hal] • Empirical measures of productivity [Hal] • Only one species targeted for compensation [Van] • Based on hypothetical cost of construction of a lake [Van]

Raw data Case Study #4 – Dam Emergency Repair

Question	Common	Additional
1.	• Fish habitat is present [Hal,Win,Van]	• Information to adequately assess what's there presently, potential impacts, compare to success of any compensation lacking [Van] • Impacts anticipated – sediment release del sub not authorized [Van] • blasting involved, therefore habitat is disrupted [Win] • Local and downstream impacts destruction of habitat ie spawn, rearing, food supply, riparian re upland access [Van]
2.		• Known methods such as timing window [Win] • Alternative methods for installation; dry crossing [Win] • Directional drill, coffer dams/dam and pump, over-stream bridge [Win] • Alternate locations – pipeline alignment route selection [Win] • Mitigation [Win] • timing window; minimize duration of instream work [Win] • Work from both sides [Win] • Longer work days [Win] • Sediment and erosion control [Win] • No mitigation possible? [Hal] • Not available? [Hal] • Emergency situation? A real one? [Hal] • Do we have something on file for that dam or river [Hal] • Knowledge, experience, case studies, species, type of habitat; speaks to redesign, mitigation measures [Van] • Uncertainty or certainty [Van] • Public input concern [Van] • Other legislation regulators [Van] • Feasibility techniques [Van] • Cost benefit, but not on its own [Van]
3.	• General guidelines [Win,Van]	• Yes, review plan and add additional mitigation if necessary (no mitigation measures provided in this case history) [Win] • Blasting, LDG [Van] • But always site specific variances [Van]
4.	• Assume they have exhausted all alternatives (relocate, redesign, mitigation) [Win] • Emergency situation? Does it influence the decision? [Hal] • Compensation is possible, on site, same ecological unit [Hal] • compensation measures are available to achieve no net loss [Win]	• Is it a "critical" habitat? No [Hal] • Expect no permanent/long term impacts [Win] • Assume no loss of spawning habitat, juvenile rearing habitat [Win] • (Monitoring program to verify assumptions) [Win] • Limiting factors (Habitat) [Van] • Habitat type is critical [Van] • Benefactor of project – public, private [Van] • Work bad time factor [Van] • Precedence [Van] • Proponent reputation [Van] • Public concern [Van] • Compensation adequate acceptable [Van]
5.	• Critical or highly productive salmonid spawning habitat [Hal,Win,Van] • Unique habitat? [Hal,Win,Van] • Endangered species? [Hal, Van] • Bottleneck type of habitat? [Hal,Van] • Fish, fishery, uniqueness, endangered, value of habitat [Hal,Van]	• Improper timing window [Win] • Policy, politics [Van] • What is high production or even high potential of productivity? [Hal] • In that case, no circumstances for exclusion. [Hal] • Risk assessment of works [Van]
6.		• First level of the hierarchy [Hal] • No mention of what the compensation proposal is (compensation area is 50% larger than the HADD area) [Win]

		• Looks like the compensation is to increase productivity for the same fish species over a 50% larger area [Win] • Subjectivity – unit, region, rec inconsistencies [Van]
7.		• Directives on type and size of habitat compensation required and monitoring [Hal] • Onus is on the proponent to develop a compensation plan; DFO negotiates with proponent/consultants etc. Yes, we give guidance. [Win] • Emergency, so first a broad agreement, included in the authorization. Fine tuning afterward. [Hal] • Emergency, we can expect the proponent to ask for a lot of directives. Adaptive management could have been considered [Hal] • A large one [Van]
8.		• ? looks like an adaptive plan based on a 5 year monitoring plan [Win] • Spatially [Van] • Subjectively [Van] • Guidelines [Van] • Transfer of practice from one area to another [Van] • Getting back more than what was lost (subjective) [Van] • What is long term? [Van] • 1 for 1, on site, same ecological unit [Hal]

Raw data Case Study #5 – Hydro-electric development

Question	Common	Additional
1.	• migration barrier (1st nations consultation) [Win,Van] • Obstruction [Win,Van]	• 3.5 km (11.5 ha pond created) [Win] • diversion of water, therefore conditions in receiving water, biota transfer [Win] • Loss of stream habitat [Van] • Change to WQ [Van]
2.	• Reduced from 3 dams to 1 dam [Win,Van]	• Is dam necessary? Is "no" an option? (re other development in the area) [Win] • Were all operational options explored (i.e. run-of-river)? [Win] • Power smart options explored [Win] • flow (rule curve) [Van] • good engineering practices [Van]
3.	• Yes, in house discussion [Win] • Yes, documents/guidelines, timing, etc./consultations [Win,Van]	• Mitigation – construction, operation [Win] • Instream flow needs – IFIM/PHABSIM [Win]
4.		• FHM trenches: [Win] • Is compensation possible? [Win] • Can we meet NNL policy? [Win] • Lose river to gain pond?? [Win] • Lose BT, walleye, sturgeon?? No sp details [Win] • OK or no; overriding social needs? ⇒ power generation in the area, jobs [Win] • Total replacement of habitat [Van] • High probability of success (low risk?) [Van] • Maintenance for dam life [Van] • Will we have equally healthy, productive river [Van]
5.	• Would dam development = loss of invaluable component of habitat = loss of valued species/population? [Win,Van] • Regional considerations (uniqueness) [Win,Van]	• Spawning [Van] • Ability for compensation to achieve NNL [Van]
6.	•	• If OK, damage, @ site is dewatered [Win] • Next, off-site compensation, like for like re species [Win] • Well down in the hierarchy [Van] • Why? – not high direct fish use habitat, replaceable, only opportunity [Van]
7.	• FHM directs compensation in general [Win,Van] • Compensation proponent takes lead and DFO responds [Van]	• Talk to province and 1st nations (other stakeholders) [Win] • Other species options? [Win] • Review compensation proposal (developed by proponent) [Win] • DFO gives more formalized guidance on mitigation (esp. hierarchy) [Van] • FM guidelines for area [Win]
8.	•	• NNL? [Win] • Ratio? (insurance policy) [Win] • 'comfort level' [Win] • Good basic biology/data and gum boots biology [Van] • Fish use [Van] • Food productivity (productive capacity) [Van] • Flow needs [Van] • Habitat status (where can it be improved?) [Van]

Appendix B – Defining Compensation Hierarchy

In order to test specific ideas effectively and unambiguously, the words and concepts used in a question must be explained clearly with definitions and examples. The following are definitions that we derived for the purpose of standardizing the assignment of hierarchy preferences across regions. Examples of case studies fitting a particular hierarchy are also suggested, where appropriate, from the relational database of case studies.

1. Create like habitat at or near the development site to benefit affected populations
- create same habitat type, not over existing aquatic habitat.

e.g. 1.1 destroy riffle – create new riffle at or near site where no fish habitat previously existed (assuming no uncertainty that efficacy is 1:1.

*e.g. 1.2 destroy **emergent** vegetation and **wetland** northern pike **spawning** grounds – create **emergent** vegetation and **wetland** northern pike **spawning** grounds at or near site where **no fish habitat** previously existed by excavating the terrestrial/riparian portion of the shoreline, seeding emergent plants, and creating wetlands.*

Case study: Project ID69, Keenleyside Powerplant Project: Construction of diversion canal, powerplant and transmission line (was old hierarchy 1 of 5).

2. Increase like habitat productivity at or near the development site to benefit affected populations
- create same habitat type over an existing lower productive habitat type

e.g. 1.1 destroy riffle – create riffle from a pool at or near site (assuming that pools are less productive than are riffles, for the affected population). Because of existing pool habitat productivity, the area of riffle created will be a larger area (i.e. >1:1).

*e.g. 1.2 destroy **emergent** vegetation and **wetland** northern pike **spawning** grounds – create **emergent** vegetation and **wetland** northern pike **spawning** grounds at or near site in the **existing** water body by dumping infill to decrease water depth, seeding emergent plants, and creating wetlands.*

Case Study: Project ID –1990193807, Etobicoke Motel Strip (was old hierarchy 3 of 5).

3. Create unlike habitat at or near the development site to benefit affected populations
- create different habitat type, not over an existing habitat

e.g. 1.1 destroy riffle – create pool at or near site where no fish habitat previously existed.

*e.g. 1.2 destroy **emergent** vegetation and **wetland** northern pike **spawning** grounds – create **submergent** vegetation northern pike **nursery** grounds at or near site where **no fish habitat** previously existed by excavating the terrestrial/riparian portion of the shoreline and seeding submergent plants.*

Case study: Project ID52, Pike Lake Pumping and Inlet Works Project (was old hierarchy 3 of 5).

4. Increase unlike habitat productivity at or near the development site to benefit affected populations
- create different habitat type over an existing lower productive habitat type

e.g. 1.1 destroy riffle – create larger pool area.

*e.g. 1.2 destroy **emergent** vegetation and **wetland** northern pike **spawning** grounds – create **submergent** vegetation northern pike **nursery** grounds at or near site in the **existing** water body by dumping infill to decrease water depth and seeding submergent plants.*

5. Create or increase habitat in a different ecological unit to increase the productivity of a different population of the same species

e.g. 1.1 destroy riffle in Stream Y that brook trout use – create riffle (or pool?) for use by brook trout in Stream Z (could be same watershed or different – distance is an issue)

*e.g. 1.2 destroy **emergent** vegetation and **wetland** northern pike **spawning** grounds – create new aquatic habitat or alter existing habitat for use by northern pike populations in a different ecological unit than the one being destroyed.*

? 'Different ecological unit' is unclear since no explicit formula is given to identify what a different unit is. Spatial separation could be criteria for identifying a different ecological unit. For example, a different lake or different section in a large lake could be a different ecological unit for allopatric (relating to or being two populations whose ranges are geographically separate and thus cannot interbreed) or parapatric (of or relating to species that live in separate but adjoining habitats) populations. However, as is the case for sympatric (describing different populations

that live in the same geographical area) populations, spatial scale is not an adequate criteria for identifying different ecological units. Ecological unit should be defined for the purpose of the *Fisheries Act*. Alternatively, it may be sufficient to create or increase habitat for the species whose habitat has been destroyed, and to do so as closely as possible (geographically) to the HADD, without mention of the term 'ecological unit'.
Case study: Project ID47, (was old hierarchy 2 of 5).
Case study: Project ID55, (was old hierarchy 4 of 5).
Case study: Project ID 944162598, (was old hierarchy 4 and 5 of 5).

6. Create or increase habitat in a different ecological unit to increase the productivity of a different species
e.g. 1.1 destroy riffle in Stream Y that brook trout use – create riffle (or pool?) for use by rainbow trout in Stream Y
*e.g. 1.2 destroy **emergent** vegetation and **wetland** northern pike **spawning** grounds – create new aquatic habitat or alter existing habitat for use by different species in a different ecological unit than the one being destroyed.*

7. Utilize rare measures such as deferred compensation, restoration of contaminated areas, or artificial production.